Acoustic Tomography With Navy Sonars

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LONG-TERM GOALS

The long-term goal of this contract is to determine if a wide variety of Navy sonars can be used to map the sound speed field by means of acoustical tomography for use in research and surveillance.

The Sound Surveillance Systems (SOSUS) have traditionally been used for obtaining acoustical tomography data. The Navy has many more sonars than these, and their use should significantly enhance the accuracy and resolution of the maps.

OBJECTIVES

We will utilize different types of active and passive Navy sonars, and electronically controlled acoustic sources deployed by scientists, to determine if Navy sonars can be used to make tomographic maps using a Kalman filter. In particular, we will utilize data from towed arrays, which should provide a synthetic aperture for increasing the resolution and accuracy of tomographic maps (Spiesberger *et al.*, 1997). We need to determine if the data from towed arrays have sufficient signal-to-noise ratios, and if the acoustic paths can be identified from a model, as has been demonstrated with data collected at SOSUS stations (Spiesberger and Metzger, 1992, Norris *et al.*, 1998). Our objective is to compare tomographic maps from towed arrays with those from only SOSUS stations in order to compare the advantages and disadvantages of using towed arrays.

APPROACH

To assess the efficacy of using SOSUS stations and fixed sources for mapping the sound speed field, a four-dimensional Kalman filter is used to map sound speed from hydrographic and tomographic data collected from May through September of 1987 (Figure). The tomographic data consist of nine sections between three source and three stations. This acoustical configuration is about as much as one could hope to afford. The dots indicate the locations of all available hydrographic data at that time. The same Kalman filter will be used to map tomographic data recorded on towed arrays. The principal investigator will collaborate with Andrew Jacobson on the tomographic aspects of this program.

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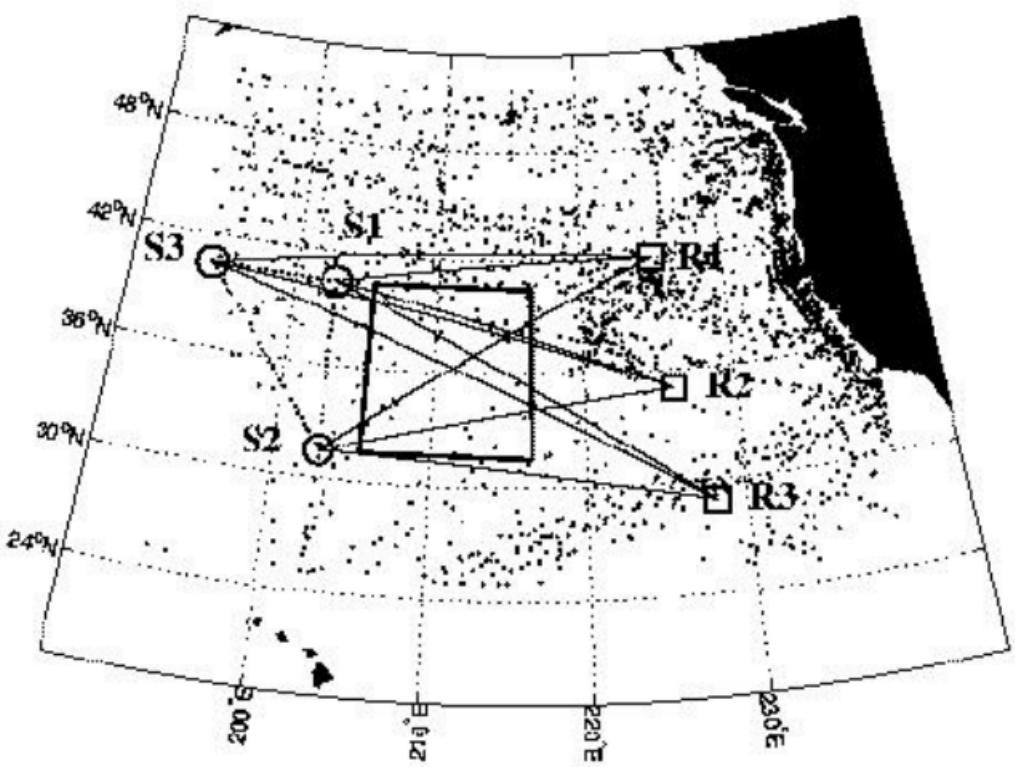

Nine tomographic sections between three fixed sources and three SOSUS stations in May-September 1987. The dots give the locations of available hydrographic data during this period.

WORK COMPLETED

The sound speed field in the northeast Pacific has been estimated using the data shown in the figure using a Kalman filter. This work was led by Andrew Jacobson at the Pennsylvania State University as part of his Ph.D. thesis.

RESULTS

There appear to be three principal results ascertained from the Kalman filter applied to the data shown in the figure so far. First, the tomographic and hydrographic data separately yield statistically consistent results for the average speed of sound in the 1000 by 1000 km volume outlined in the Figure in the layers from 0-100 m and 100-300 m depth. The consistency of these values supports the interpretation of the acoustic data. Second, the average speed of sound within the volume is colder than predicted from climatology with a confidence of 95%. Third, the hydrographic data yield more accurate maps of the average sound speed within the volume than from the tomographic data. This came as a surprise to the principal investigator. Until further analysis is done, not much more can be proven, but it appears that the sound speed field has a spatial structure that is better sampled from ships than from this fixed tomography array. The structure of the sound speed field is probably dominated

by Rossby waves related to El Nino and the Southern Oscillation (Spiesberger *et al.,* 1998*).* It is not yet known what the relative merits of hydrographic and tomographic data are when average values of sound speed are made in volumes of larger extent than 1000 by 1000 km in the upper ocean.

IMPACT/APPLICATIONS

If available hydrographic data can better map the large-scales in the ocean than tomographic systems consisting of fixed sources and SOSUS stations, then it appears that it may be necessary to rely on synthetic apertures from towed arrays or towed sources to obtain the desired accuracy and resolution. A goal of this contract to ascertain if towed arrays do indeed provide much better maps of the sound speed field than either hydrographic data or data obtained from SOSUS stations and fixed sources.

TRANSITIONS

The results of this research are not yet utilized by the operational Navy.

RELATED PROJECTS

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